Tritium Science and Technology at AWE

Tritium Focus Group Meeting – 3-5 Nov 2015

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About AWE

- The **Atomic Weapons Establishment** has been at the forefront of the **United Kingdom's nuclear deterrent** programme for more than 60 years.
  - *Continuous At Sea Deterrent.*
  - *National Nuclear Security.*
  - *Support non-proliferation and CTBTO.*
- AWE works under contract to the **Ministry of Defence** in a government-owned-contractor-operated (**GOCO**) arrangement.
- Operation of the sites is through **AWE (ML)** made up of three equal shareholders – Jacobs Engineering Group, Lockheed Martin Corporation and Serco Group.
- Operates from two main sites in Berkshire, AWE Aldermaston and AWE Burghfield, with additional facilities at Blacknest and RNAD Coulport.

Our Commitment and Values

Building on our **proud** heritage,
our **excellent** people and technologies,
we will create a unique and
internationally recognised,
trusted partner to UK Government,
delivering **innovative** and integrated
national nuclear security
solutions.

A distinguished history of safeguarding the Nation for almost 60 years

Nuclear know-how and technical expertise, past, present and future

At the forefront of non-proliferation and counter-terrorism strategies

Positioning ourselves at the heart of government as the leading national nuclear defence contractor

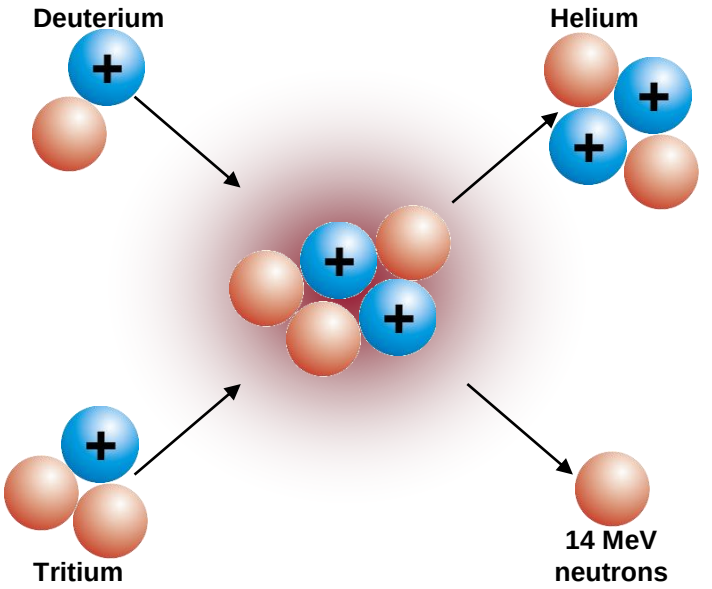
World-leading technology and ground-breaking science, expanding the boundaries of our core mission

Tritium @ AWE

- AWE has a history of working with tritium dating back to the 1960's.
- The tritium research facility in the photograph is now a parking lot!
- Environmental testing for tritium.
- Bio-assay for tritium.
- Fundamental tritium-materials research and $^{1}H/^{2}D/^{3}T$ isotope effects.
- AWE set up and ran the UK Tritium Users Group from 2003-2014.

Tritium Science and Technology

- Tritium may be used in **modern warheads**.
  - **Reduces** mass of fissile material required.
- **Stewardship** of the inventory.
  - Historic R&D **legacy management**.
  - Analysis and recovery.
- **Fundamental R&D**
  - Collaboration with Systems Engineering and Systems Assessment and Integration Group.
  - Salford University key interaction on behaviour of **hydrogen in metals**.
  - Interactions with civil sector in support of wider UK tritium programmes.
- **Bespoke capabilities**
  - Interaction of hydrogen isotopes with materials.
  - Tritium processing, handling and safety
  - Assay and analysis techniques.

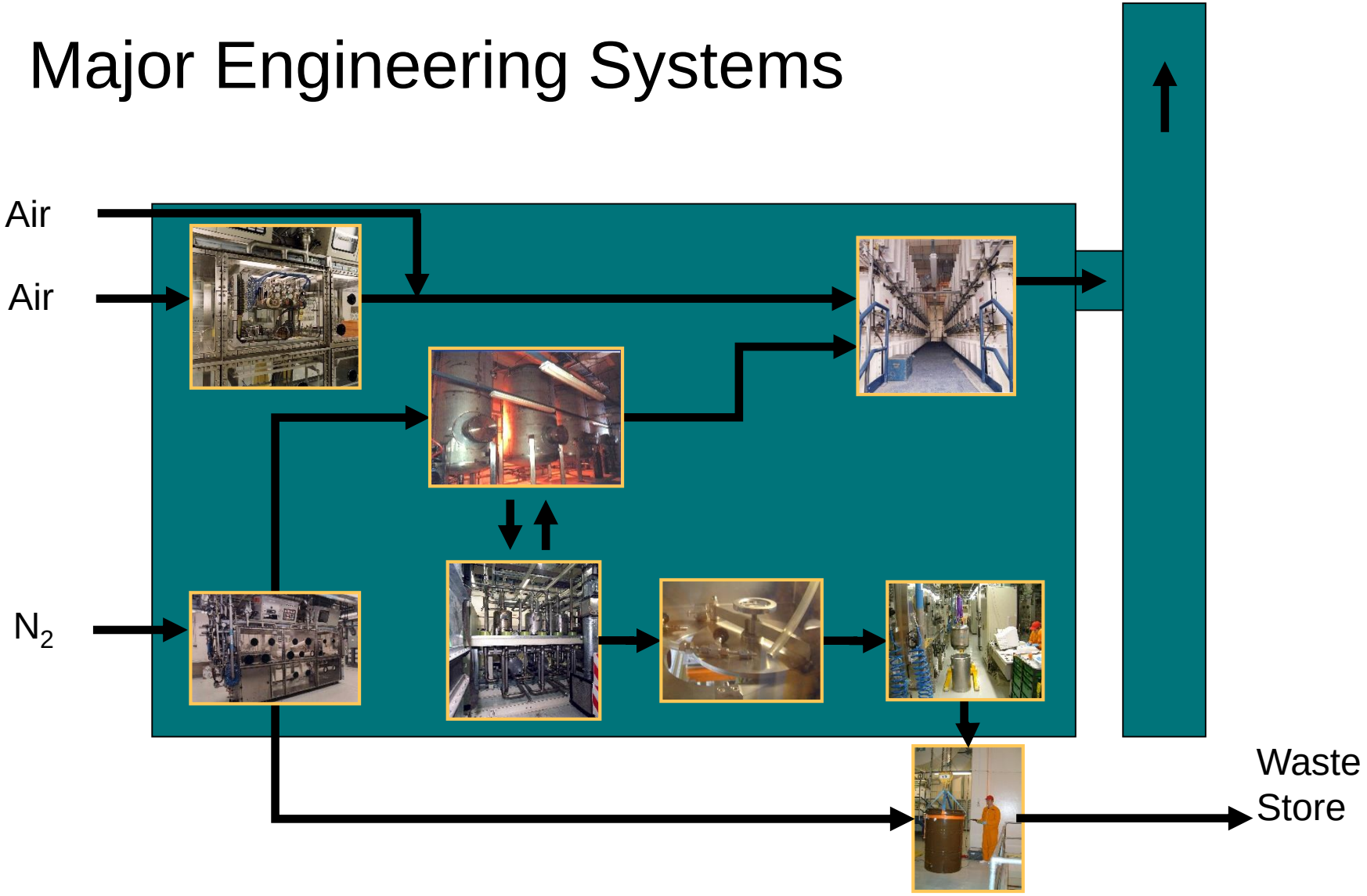


Tritium Science Capabilities

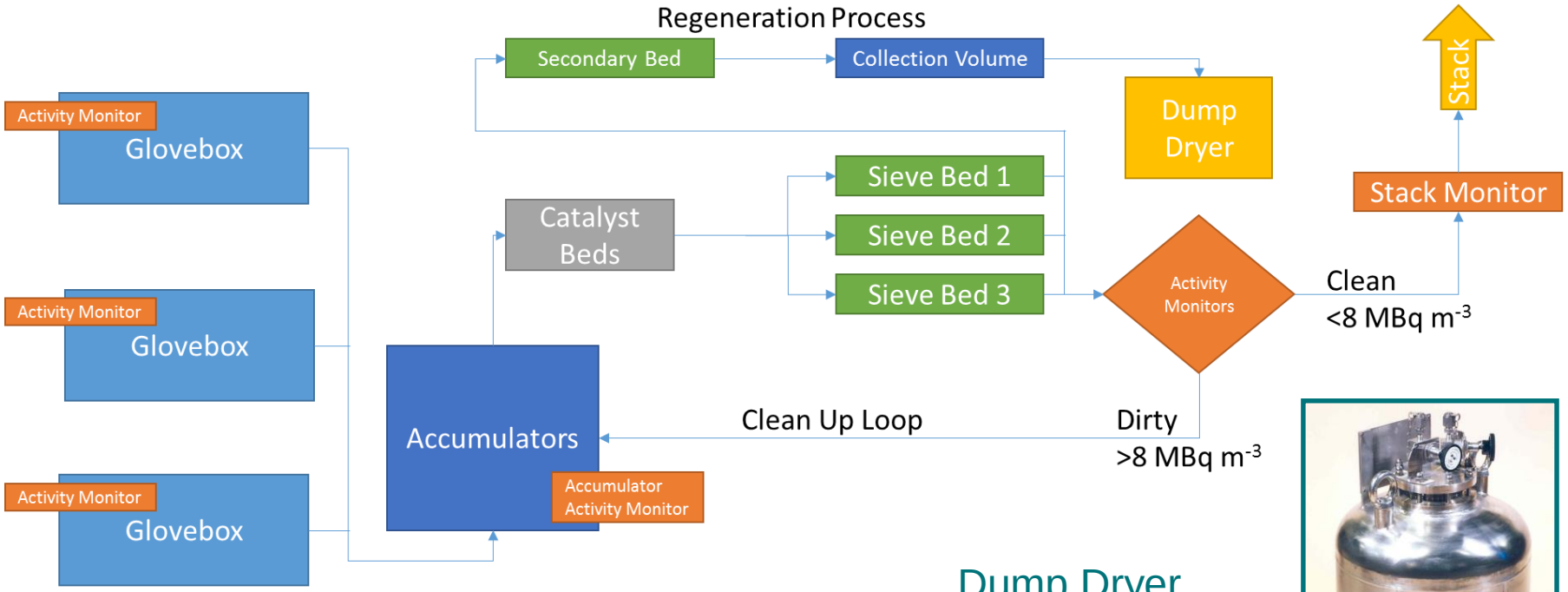
- To undertake work on tritium programmes in support of CASD.
- Purpose built science facility with consent to operate from NII (now the ONR) Dec 2002.
- Key Design Features.
  - Distributive Control System to monitor plant condition.
  - Monitoring of workspace, containments and discharges.
  - Remotely operated process lines.
  - HVAC system.
  - Inert gas gloveboxes.
  - Gas Clean Up Plant.

Tritium Science Facility (cont.)

Major Engineering Systems



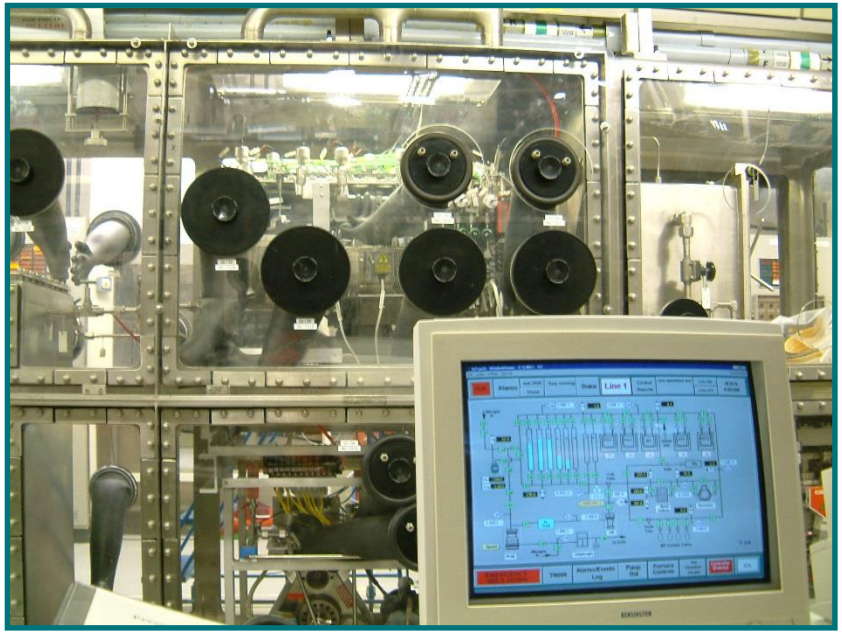
Gas Clean Up System Overview



GCUS – Discharges from all gloveboxes and lines, including Mass Spec & House Vacuum

Dump Dryer
Mol. Sieve based long term storage

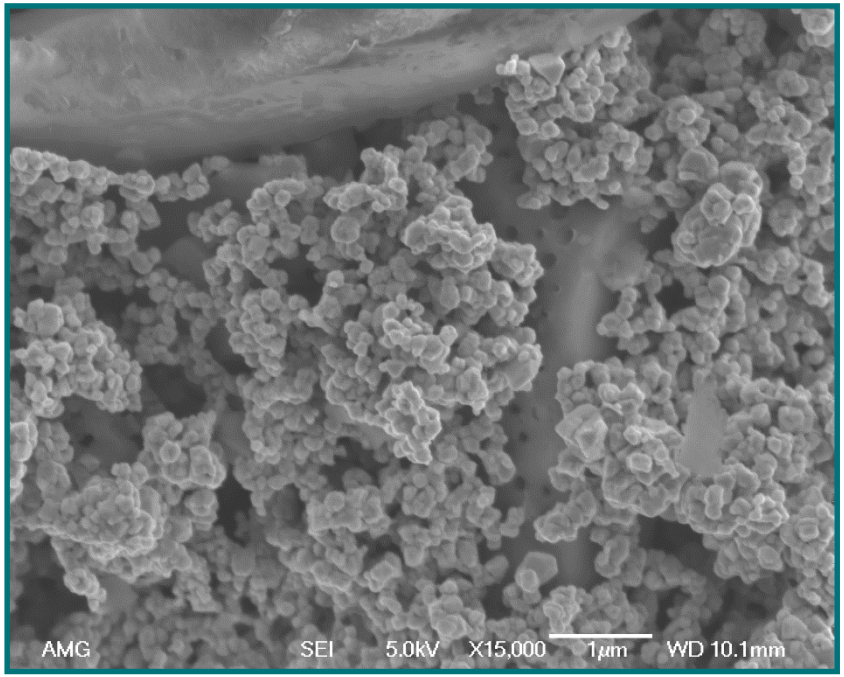
Baseline capability



- Processing tritium.
- Preparing gas mixtures.
- H/D materials research.
- Determining activity ‘hold up’ in waste.
- De-tritiation of glove-box effluent.
- Analysing gas mixtures by mass spectrometry.
- Measuring stored inventory by calorimetry.

Capability uplifts

- Tritium thermodynamics glovebox.
- Isotope separation capability.
- Hydrogen laboratory upgrade.
- Furnace ‘watch-dog’ systems.
- Hi-Res mass spectrometer.
- Raddec Pyrolyser.
- Packard 308 Oxidiser.
- Acid Dissolution Line.



Palladium on Kieselguhr for isotope separation capability

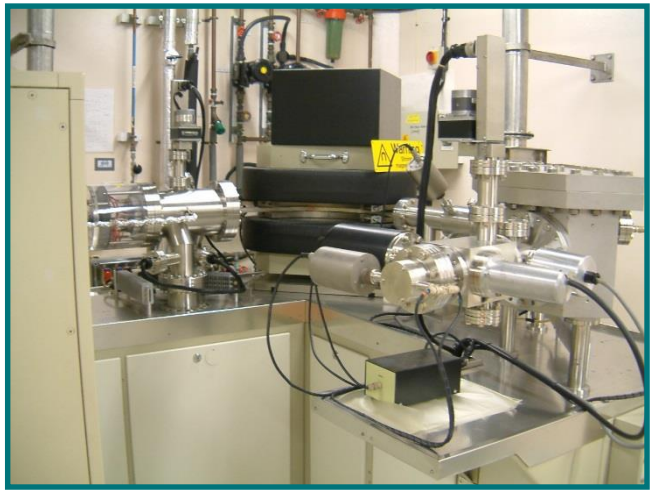
Tritium Calorimetry

- Large twin-cell design.
  - Accommodates a wide range of samples in secondary containment.
- Utilises heat-flow method.
  - No requirement for additional cooling
  - Measurement time 2-4 days, dependant on packaging.
- Measurement range 0.5mW – 5W (~0.55TBq – 5500TBq = 15Ci – 150kCi)
- Excellent relationship with the manufacturers (Antech) due to proximity to site.

Ref: *C. Knott, A. Provenzano, A. S. A. Roffey,* Comprehensive Performance Analysis of Large Volume Twin Cell Heat-Flow Calorimeters for Tritium Assay, Presented at the 55th Annual Meeting of the Institute of Nuclear Materials Management, July **2014**.

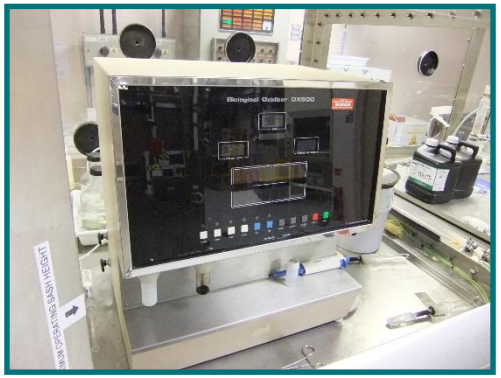
High resolution mass spectrometry

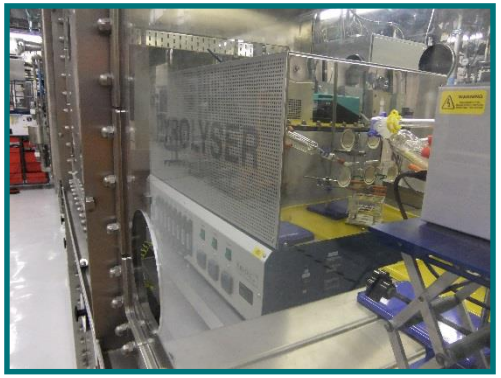
- Gas composition analysis pre- and post-processing.
  - High resolution required to separate species with same nominal mass (e.g. ^{4}He & HT).
- Double focussing, magnetic sector instrumentation.
  - VG 30-38.
  - Nu Instruments Evolution (to be commissioned).
- Regular updates to US community via the Gas Technology IMOG.



Combustion Techniques

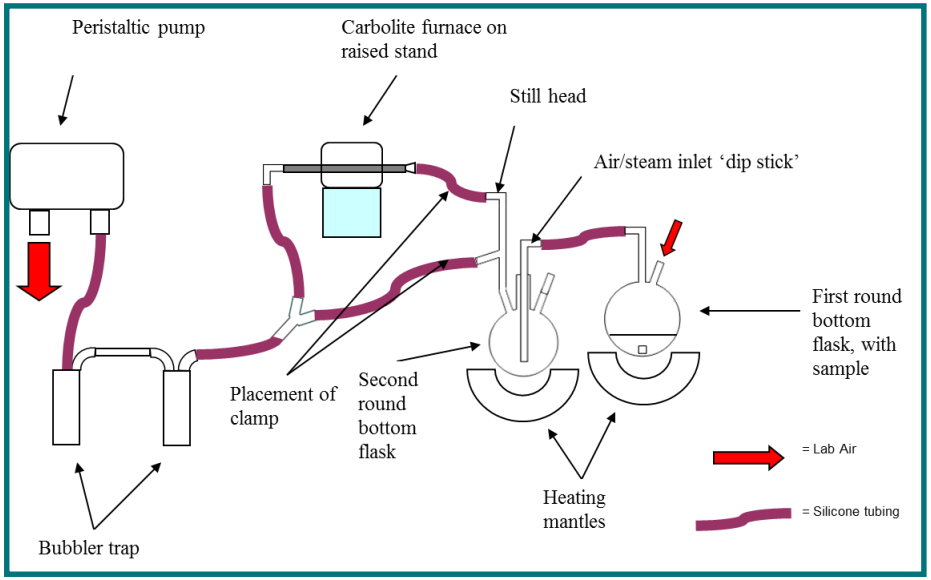
- Underpinning method for ‘soft’ waste assay to determine contamination levels (legislative compliance).
- RJ Harvey OX500 & Packard Model 307.
  - Small sample size, high throughput.
  - Packard undergoing method development.
- Raddec Pyrolyser.
  - 6 tube furnace with 3-zone programmable temperature control.
  - Larger sample masses, wider range of materials.
- Samples assayed using Perkin Elmer Tricarb liquid scintillation counters.





Acid Dissolution*

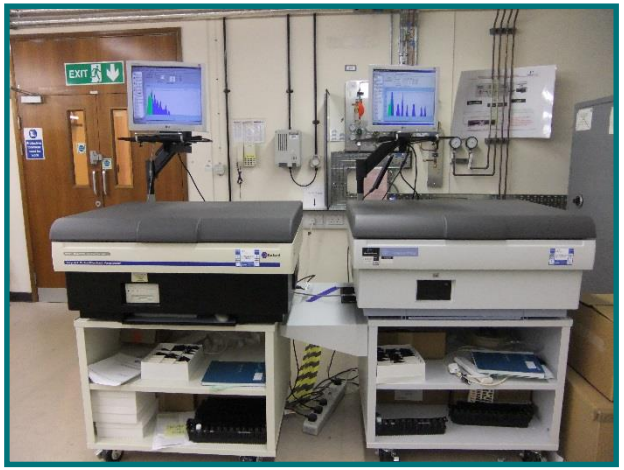
- Total tritium content of metals to support waste sentencing.
- In-house design to replace a previous all-glass system (with issues).
- Small scale system to be used in parallel with higher throughput combustion methods.
  - Commissioning with stainless steel.
  - Spiked and un-spiked samples used to determine process efficiency.
- Samples assayed using Perkin Elmer Tricarb liquid scintillation counters.



* To be presented at Tritium 2016

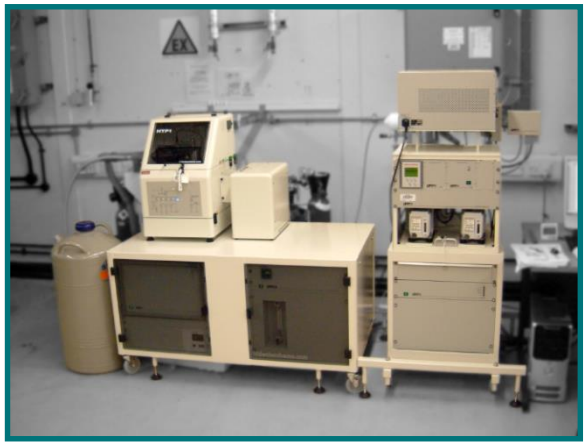
Liquid Scintillation Counting

- Current systems - TriCarb 3170 TR/SL LSA's.
  - BGO detector guard for ultra-low level counting.
  - Very low background – longer count time.
  - Max. Capacity ca. 400 vials each.
  - Upgrade to Quantulus GCT completion is imminent.
- Hidex.
  - 3 PMTs enables TDCR counting.
  - No internal/external source needed.
  - Batch screening.
  - Max. Capacity 50 vials.
- Triathler.
  - High throughput screening.
  - Single vial capacity.



Hydrogen (and Deuterium) Laboratory

- Sieverts' Instrument – HTP1.
- Rubotherm Magnetic Suspension Balance.
- Dilatometer.
- Differential Scanning Calorimeter.
- Simultaneous Thermal Analyser.
- Atomic Force Microscope.



Legacy and Waste Programmes

- Decommissioning of plant and equipment.
- Legislative and regulatory compliance.
- BAT for some items is disposal via third party.
  - Tritium removal and discharge.
  - Passivation (and segregation where appropriate).
  - Cementation for long term storage.
- New techniques constantly being developed.

Summary

- Active tritium science and technology teams.
- Capability investments in:
  - Facility Engineered Systems.
  - Science equipment.
- Current topics of work.
  - Properties of Pd with H & D.
  - Materials research.
  - Helium release from uranium solid storage.*
  - Helium release and effects on Pd/T.
- Interactions with US counterparts is important in validating our research.

* To be presented at Tritium 2016